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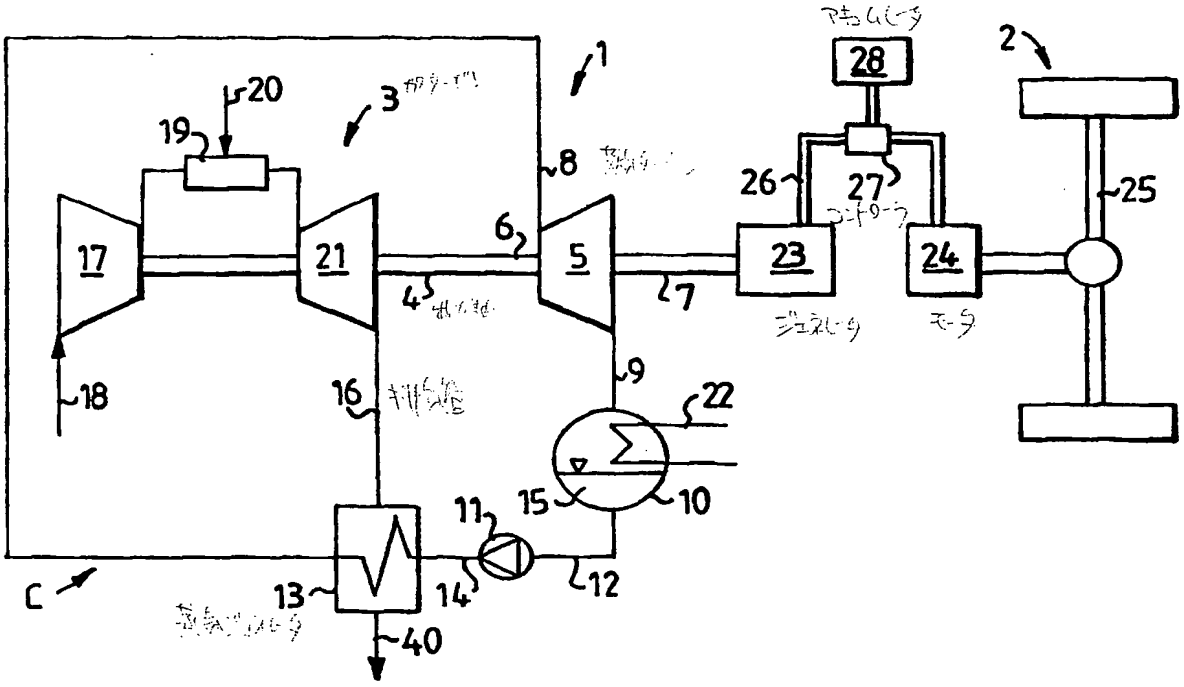

(57) Abstract

The invention relates to a drive system for a vehicle, comprising a gas turbine unit (3) with an output shaft (4). A steam power unit comprising a steam turbine (5) with a steam turbine input shaft and output shaft (6 and 7 respectively) is coupled by the steam turbine input shaft (6) to the output shaft (4) of the gas turbine unit (3). An exhaust pipe (16) arranged on the gas turbine unit (3) is coupled to a steam generator (13) forming part of the steam power unit.

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DRIVE SYSTEM FOR A VEHICLE

The present invention relates to a drive system for a vehicle, comprising a gas turbine unit with an output shaft.

It is previously known to drive a vehicle, such as a lorry or a bus, using a gas turbine unit coupled to the drive shaft of the vehicle. If appropriate, the gas turbine unit may be coupled to an electric drive system comprising a generator, an energy accumulator and an electric motor coupled directly to the drive shaft of the vehicle. Depending on how the gas turbine unit and the electric drive system are coupled together, they constitute a serial or parallel hybrid system.

Gas turbine units produce high power in relation to their weight, which is favourable for vehicle operation. An advantage of arranging a gas turbine unit in a hybrid drive system is that relatively compact permanent-magnet machines can be used in the electric drive system as the gas turbine unit operates at a high speed of rotation. However, the gas turbine unit suffers great heat losses as a large proportion of the energy is lost with the exhaust gases of the gas turbine unit. This means that the overall efficiency of the drive source remains relatively low.

The object of the present invention is to increase the overall efficiency of a drive system of which a gas turbine unit forms part.

A further object of the present invention is to utilize essentially all the heat losses of a gas turbine unit in order to increase the overall efficiency of a drive system.

A further object of the present invention is to generate electricity from the heat losses of a gas turbine unit.

These objects are achieved according to the invention by virtue of the fact that a steam power unit comprising a steam turbine with a steam turbine input shaft and output shaft is coupled by the steam turbine

input shaft to the output shaft of the gas turbine unit, and that an exhaust pipe arranged on the gas turbine unit is coupled to a steam generator forming part of the steam power unit.

Such a drive system provides high overall efficiency as essentially all the heat losses of a gas turbine unit are lost with the exhaust gases. When the exhaust gases are led through the steam generator so as to evaporate a medium contained in a closed circuit, a very large proportion of the heat losses of the gas turbine unit are thus utilized in order to increase the overall efficiency of the drive system. Calculations have shown that an overall efficiency of around $\eta = 40\%$ can be achieved.

The invention is described in greater detail with reference to exemplary embodiments shown in the appended drawings, in which

Fig. 1 shows a serial hybrid drive system for a vehicle according to a first embodiment,

Fig. 2 shows a parallel hybrid drive system for a vehicle according to a second embodiment,

Fig. 3 shows a direct-coupled drive system according to a third embodiment,

Fig. 4 shows a drive system for a vehicle according to a fourth embodiment with a thermoelectric generator coupled to the drive system,

Fig. 5 shows a drive system for a vehicle according to a fifth embodiment with a thermoelectric generator coupled to the drive system,

Fig. 6 shows a drive system for a vehicle according to a sixth embodiment with a thermoelectric generator coupled to the drive system,

Fig. 7 shows a drive system for a vehicle according to a seventh embodiment with a thermoelectric generator coupled to a gas turbine unit,

Fig. 8 shows a drive system for a vehicle according to an eighth embodiment with a thermoelectric generator coupled to a gas turbine unit,

Fig. 9 shows a drive system for a vehicle according to a

ninth embodiment with a thermoelectric generator coupled to a gas turbine unit, and

Fig. 10 shows diagrammatically a sectioned view of a thermoelectric generator.

In Fig. 1, reference number 1 indicates generally a drive system for a vehicle 2. The drive system 1 comprises a gas turbine unit 3 which is coupled by an output shaft 4 to a steam turbine 5. The steam turbine 5 comprises a steam turbine input shaft and output shaft 6 and 7 respectively, the output shaft 4 of the gas turbine unit 3 being coupled to the steam turbine input shaft 6. An inlet pipe and an outlet pipe 8 and 9 respectively are coupled to the steam turbine 5, and a condenser 10 is coupled to the outlet pipe 9 of the steam turbine. A feed pump 11 is coupled to the condenser 10 by means of a first pipe 12, and a steam generator 13 is coupled to the feed pump 11 by means of a second pipe 14, which steam generator 13 is in turn coupled to the inlet pipe 8 of the steam turbine 5 so as to form a closed circuit C which contains a working medium 15.

An exhaust pipe 16 arranged on the gas turbine unit 3 is coupled to the steam generator 13 so as to evaporate the working medium 15 contained in the closed circuit C. After the exhaust gases of the gas turbine unit 3 have passed through the steam generator 13, the exhaust gases are led out into the atmosphere through an exhaust opening 17.

The working medium 15 contained in the closed circuit C of the steam power unit preferably consists of an organic medium comprising RC318 or R13B1. The chemical formula for RC318 is C_4F_8 and the chemical formula for R13B1 is $CBrF_3$. Other organic media are also possible. A working medium 15 that provides an essentially saturated steam after the steam turbine 5 is desired as this increases the efficiency of the steam turbine 5. In the event that saturated steam cannot be obtained after the steam turbine 5, steam can be drawn off after the steam turbine 5 and supplied to a heat exchanger (not shown) which is arranged, for example, on the second pipe 14 in

order to heat the working medium 15 in the closed circuit C.

The gas turbine unit 3 can be of a conventional type comprising a compressor part 17 with an intake 18 for air. Compressed air from the compressor part 17 passes through a combustion chamber 19 to which fuel 20 is supplied and combusted in contact with the hot compressed air. The hot combustion gases expand through a turbine part 21 of the gas turbine unit 3 and are then led through an exhaust pipe 16 to the steam generator 13.

During a steam power process, the evaporated medium expands in the steam turbine 5 and is then led to the condenser 10. In the condenser 10, heat is removed by means of a cooling coil 22 which can be coupled to a heat exchanger (not shown) arranged on the vehicle 2 and cooled by the wind created by movement. In the condenser 10, the working medium 15 is converted into liquid. The feed pump 11 feeds the condensed working medium 10 to the steam generator 13 where heat from the exhaust gases of the gas turbine 3 is supplied to the working medium 15 at constant pressure. In the steam generator 13, the working medium 15 is converted from the liquid phase, via the moist steam stage, to superheated steam which is caused to expand in the steam turbine 5. The circular process is thus complete.

According to the first embodiment, the steam turbine output shaft 7 is coupled to an electricity generator 23 arranged on the vehicle 2 and intended to supply an electric motor 24 with current, which electric motor 24 is coupled to a drive shaft 25 for the vehicle 2. The electricity generator 23 is connected to the electric motor 24 by means of electric conductors 26 via a control unit 27 which, if so desired, may direct the current flow to an accumulator 28. Under certain operating conditions, current can subsequently be supplied from the accumulator 28 to the electric motor 24. A vehicle 2 driven by a serial hybrid drive system is thus obtained.

Alternatively, the steam turbine output shaft 7

can be coupled directly to the drive shaft 25 of the vehicle via a gearbox 29 as shown according to a second embodiment in Fig. 2. According to this second embodiment, which forms a parallel hybrid drive system, an electric motor 38, which can also function as a generator, is coupled to the gearbox 29. The combined electric motor and generator 38 is coupled via a control unit 27 to an accumulator 28. Under certain operating conditions, the accumulator 28 is charged by the generator and, under other operating conditions, current is fed from the accumulator 28 to the electric motor 38. According to a third embodiment, however, it is possible, as shown in Fig. 3, to have the steam turbine 5 coupled directly to the drive shaft 25 of the vehicle via the gearbox 29 without having a combined electric motor and generator 38 coupled to the gearbox 29.

According to a fourth embodiment, shown in Fig. 4, a thermoelectric generator 30 comprising an inlet opening and an outlet opening 31 and 32 respectively can be coupled by its inlet opening 31 to the exhaust opening 17 so as to be flowed through by exhaust gases that have passed through the steam generator 13. The thermoelectric generator 30 is preferably coupled by electric conductors 36 to the feed pump 11 and supplies the latter with current. Other equipment for the drive system 1 and of the vehicle 2 can also be supplied with current from the thermoelectric generator 30.

Instead of placing the thermoelectric generator 30 after the steam generator 13, the thermoelectric generator 30, as shown according to the fifth embodiment in Fig. 5, can be placed before the steam generator 13. The thermoelectric generator 30 is thus coupled by its inlet opening 31 to the exhaust pipe 16 of the gas turbine unit 3 and by its outlet opening 32 to the steam generator 13.

Alternatively, the thermoelectric generator 30 can be placed in the closed circuit C after the steam turbine 5, as shown according to a sixth embodiment in Fig. 6. The thermoelectric generator 30 is thus connected

to the outlet pipe 9 of the steam turbine 5 and to the condenser 10. According to this embodiment, the thermoelectric generator 30 is designed to be flowed through by the working medium contained in the closed circuit. In certain types of operation, the steam may still be superheated after the steam turbine 5, and so the energy contained in the superheated steam can be removed in the thermoelectric generator 30.

The embodiments described in connection with Figures 4 - 6 can be applied to the serial and parallel hybrid drive systems and also the direct-coupled system shown in Figures 1 - 3.

According to a seventh embodiment, shown in Fig. 7, the thermoelectric generator 30 can be coupled directly by its inlet opening 31 to the exhaust pipe 16 of the gas turbine unit 3, in which case the exhaust gases from the gas turbine 3 can pass through the thermoelectric generator 30 and out into the atmosphere through the outlet opening 32 of the thermoelectric generator 30 after, if appropriate, having passed through a silencer (not shown). Alternatively, the thermoelectric generator 30 can be designed as a silencer, in which case a separate silencer is rendered superfluous.

According to the seventh embodiment, the output shaft 4 of the gas turbine unit 3 is coupled directly to the drive shaft 25 of the vehicle 2 via a gearbox 29. The thermoelectric generator 30 can be coupled by means of electric conductors (not shown) to the accumulator 28 of the vehicle 2 so as to charge the latter and/or coupled to peripheral equipment (not shown) of the vehicle 2 or the drive system 1.

According to an eighth embodiment, shown in Fig. 8, an electric motor 38, which can also function as a generator, can be coupled to the gearbox 29. The combined electric motor and generator 38 is coupled via a control unit 27 to an accumulator 28. Under certain operating conditions, the accumulator 28 is charged by the generator and, under other operating conditions, current is fed from the accumulator 28 to the electric motor 38.

The system according to Fig. 8 thus constitutes a parallel hybrid drive system. The thermoelectric generator 30 can, via electric conductors 37, generate current for the combined electric motor and generator 38 or the accumulator 28 via the control unit 27.

It is also possible, as shown according to a ninth embodiment in Fig. 9, that the output shaft 4 of the gas turbine unit 3 is coupled to an electricity generator 23 which generates current for an electric motor 24 which is coupled to the drive shaft 25 of the vehicle 2. The thermoelectric generator 30 then also generates, via electric conductors 37, current for the electric motor 24 and for an accumulator 28 via a control unit 27 depending on the type of operation of the vehicle 2.

A thermoelectric generator 30 is shown diagrammatically in Fig. 10 and comprises a number of Peltier-effect elements 33 of bimetal type which each have a first surface 34, which has contact with the hot exhaust gases of the gas turbine 3, and a second surface 35 which is cooled by, for example, surrounding air or a cooling system with a heat exchanger (not shown). Electric conductors 36 are coupled to the Peltier elements 33, which conductors 36 supply the feed pump 11 and other peripheral equipment of the vehicle 2 and the drive system 1 with current generated in the Peltier elements 33 by thermoelectric effect.

Patent Claims

1. Drive system for a vehicle, comprising:
a gas turbine unit (3) with an output shaft (4), characterized in that a steam power unit comprising a steam turbine (5) with a steam turbine input shaft and output shaft (6 and 7 respectively) is coupled by the steam turbine input shaft (6) to the output shaft (4) of the gas turbine unit (3), and in that an exhaust pipe (16) arranged on the gas turbine unit (3) is coupled to a steam generator (13) forming part of the steam power unit.

2. Drive system according to Claim 1, characterized in that the steam turbine output shaft (7) is coupled directly to the output shaft (4) of the gas turbine unit (3).

3. Drive system according to either Claim 1 or 2, characterized in that the working medium (15) consists of an organic medium.

4. Drive system according to Claim 3, characterized in that the organic medium comprises RC318 which has the chemical formula C_4F_8.

5. Drive system according to Claim 3, characterized in that the organic medium comprises R13B1 which has the chemical formula $CBrF_3$.

6. Drive system according to one or more of the preceding claims, characterized in that the steam turbine output shaft (7) is coupled to a drive shaft (25) for the vehicle (2).

7. Drive system according to Claim 6, characterized in that a gearbox (29) is arranged between the steam turbine output shaft (7) and the drive shaft (25), to which gearbox a combined electric motor and generator (38) is also coupled.

8. Drive system according to one or more of Claims 1 - 5, characterized in that the steam turbine output shaft (7) is coupled to an electricity generator (23) arranged on the vehicle (2) and intended to supply an electric motor (24) with current, which electric motor

(24) is coupled to a drive shaft (25) for the vehicle (2).

9. Drive system according to one or more of the preceding claims, characterized in that a thermoelectric generator (30) comprising an inlet opening and an outlet opening (31 and 32 respectively) is coupled by its inlet opening (31) to an exhaust opening (17) for exhaust gases from the gas turbine unit (3) that have passed through the steam generator (13).

10. Drive system according to one or more of Claims 1 - 8, characterized in that a thermoelectric generator (30) comprising an inlet opening and an outlet opening (31 and 32 respectively) is coupled by its inlet opening (31) to the exhaust pipe (16) of the gas turbine unit (3) and by its outlet opening (32) to the steam generator (13).

11. Drive system according to one or more of Claims 1 - 8, characterized in that a thermoelectric generator (30) comprising an inlet opening and an outlet opening (31 and 32 respectively) is coupled by its inlet opening (31) to the outlet pipe (9) of the steam turbine (5).

12. Drive system according to any one of Claims 9 - 11, characterized in that the thermoelectric generator (30) is coupled by means of electric conductors (36) to the feed pump (11) and supplies the latter with current.

13. Drive system for a vehicle, comprising:
a gas turbine unit (3) with an output shaft (4) coupled to a drive shaft (25) for the vehicle (2), characterized in that a thermoelectric generator (30) comprising an inlet opening and an outlet opening (31 and 32 respectively) is coupled by its inlet opening (31) to an exhaust pipe (16) of the gas turbine unit (3).

14. Drive system according to Claim 13, characterized in that the output shaft (4) of the gas turbine unit (3) is coupled to an electricity generator (23) arranged on the vehicle (2) and intended to supply an electric motor (24) with current, which electric motor (24) is coupled to the drive shaft (25) of the vehicle (2).

15. Drive system according to Claim 14, characterized

in that the thermoelectric generator (30) is coupled by means of electric conductors (37) via a control unit (27) to an accumulator (28) arranged on the vehicle (2) and to the electric motor (24).

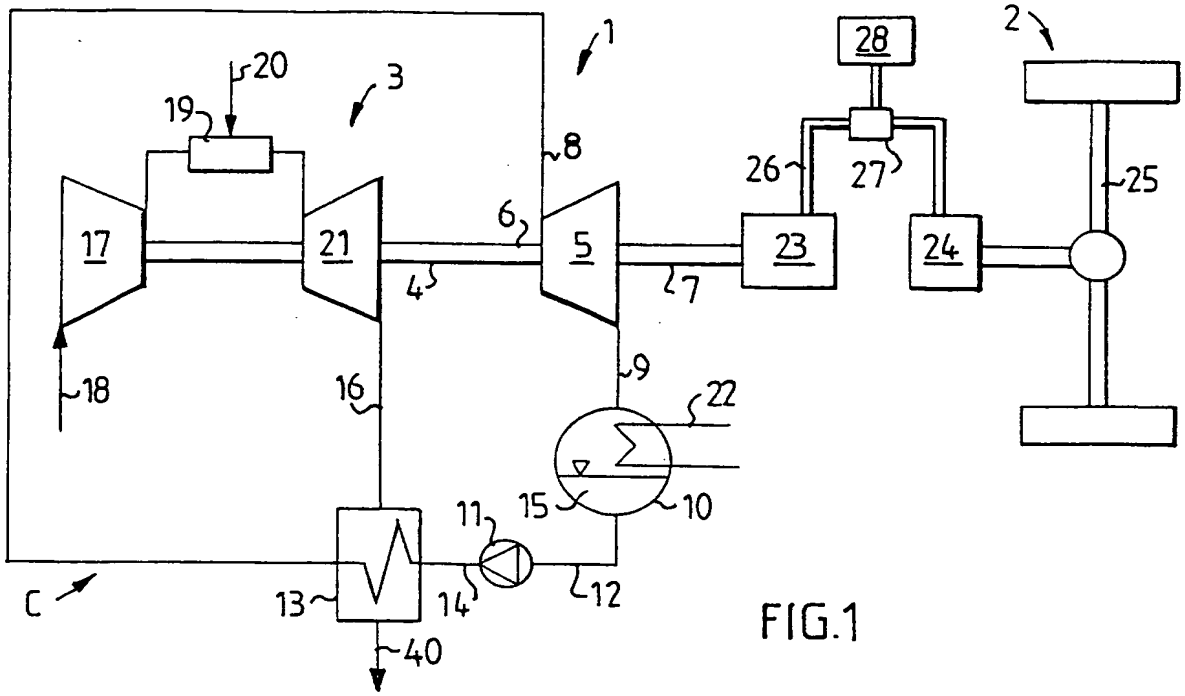

FIG.1

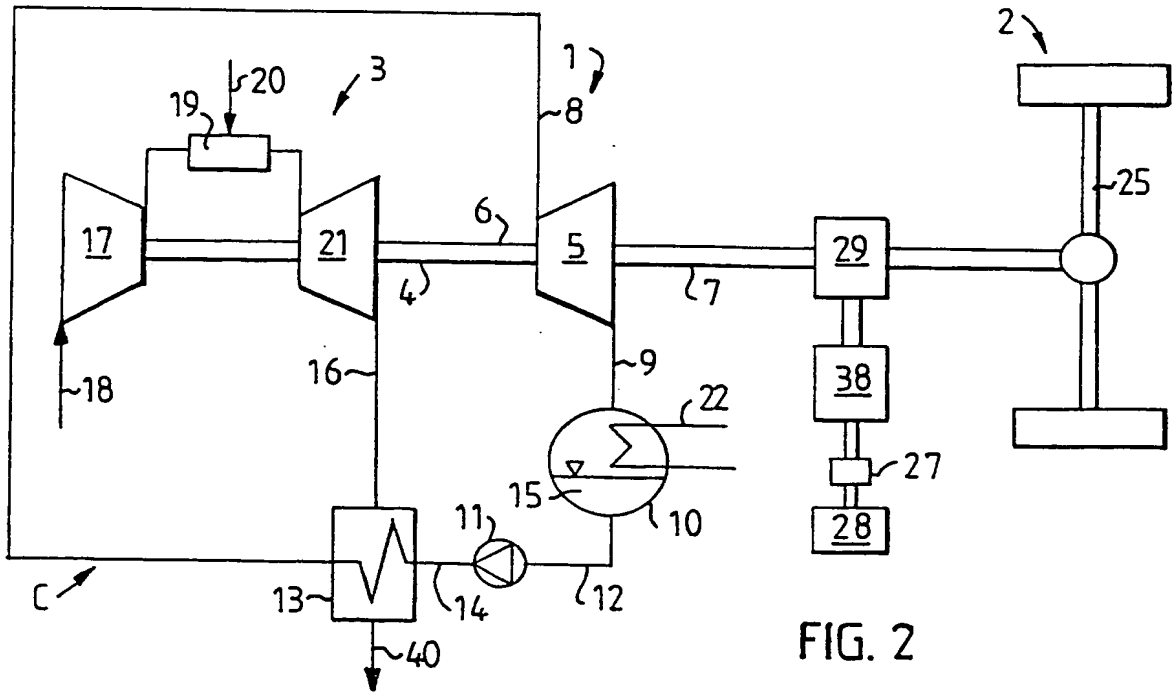

FIG. 2

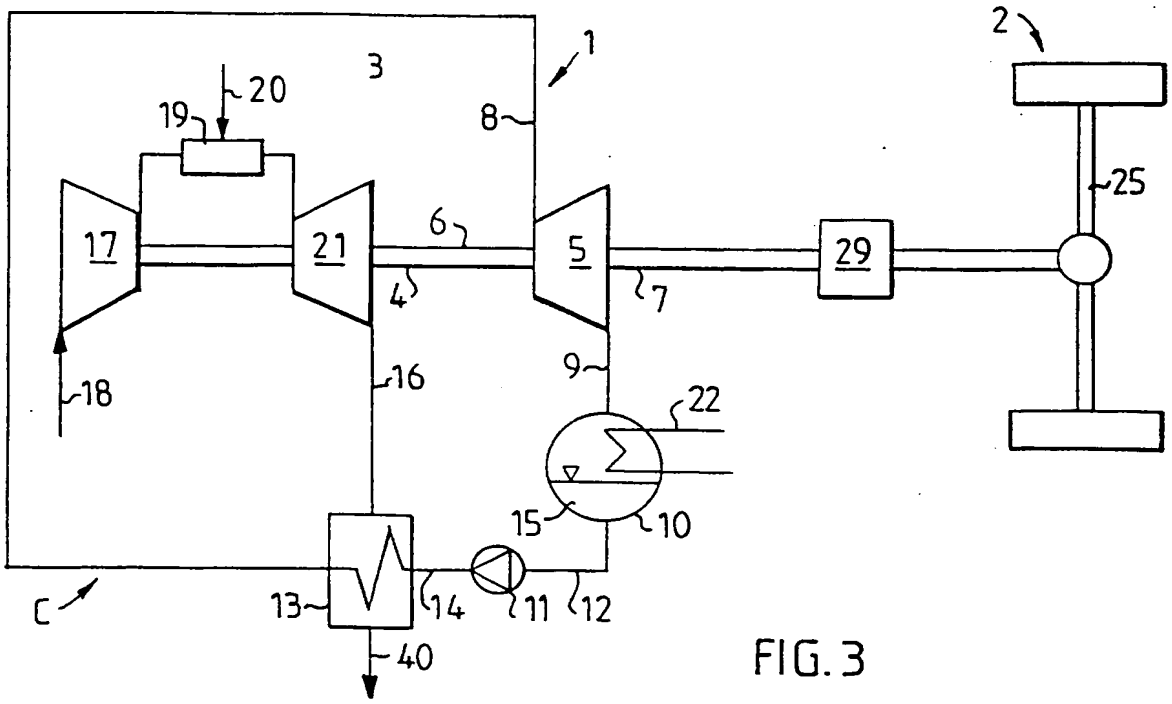

FIG. 3

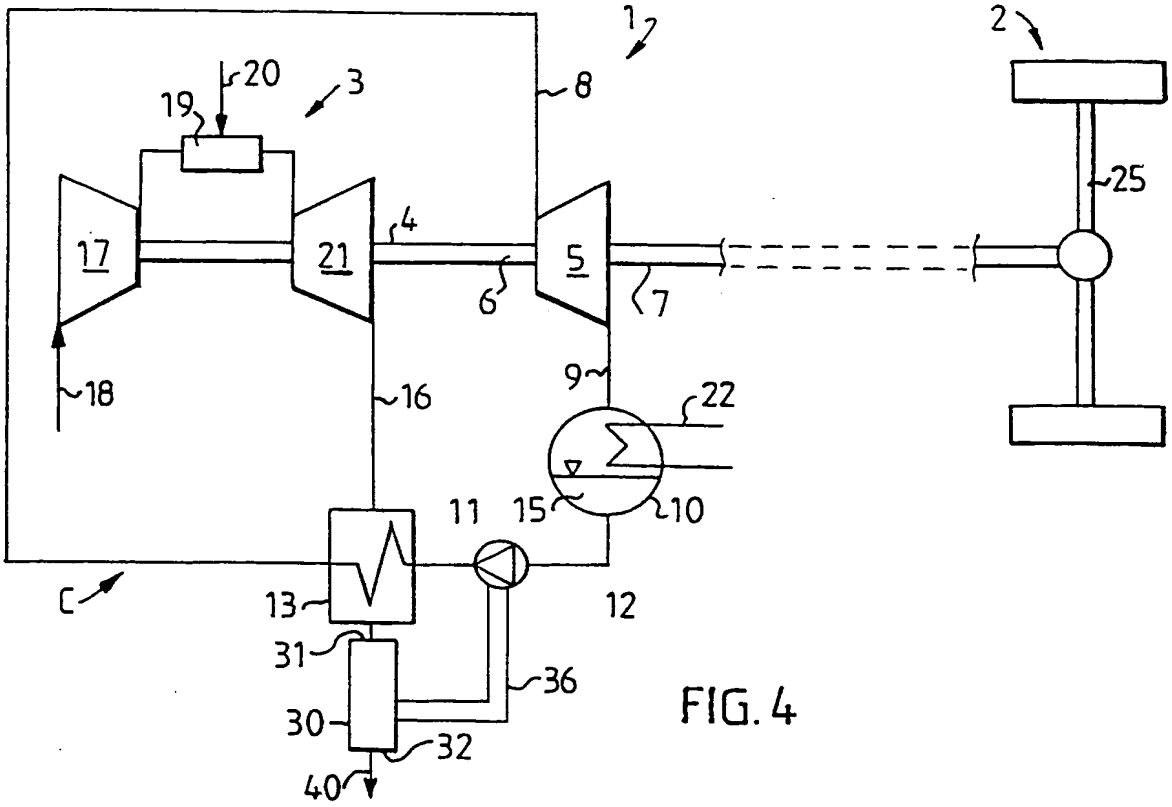

FIG. 4

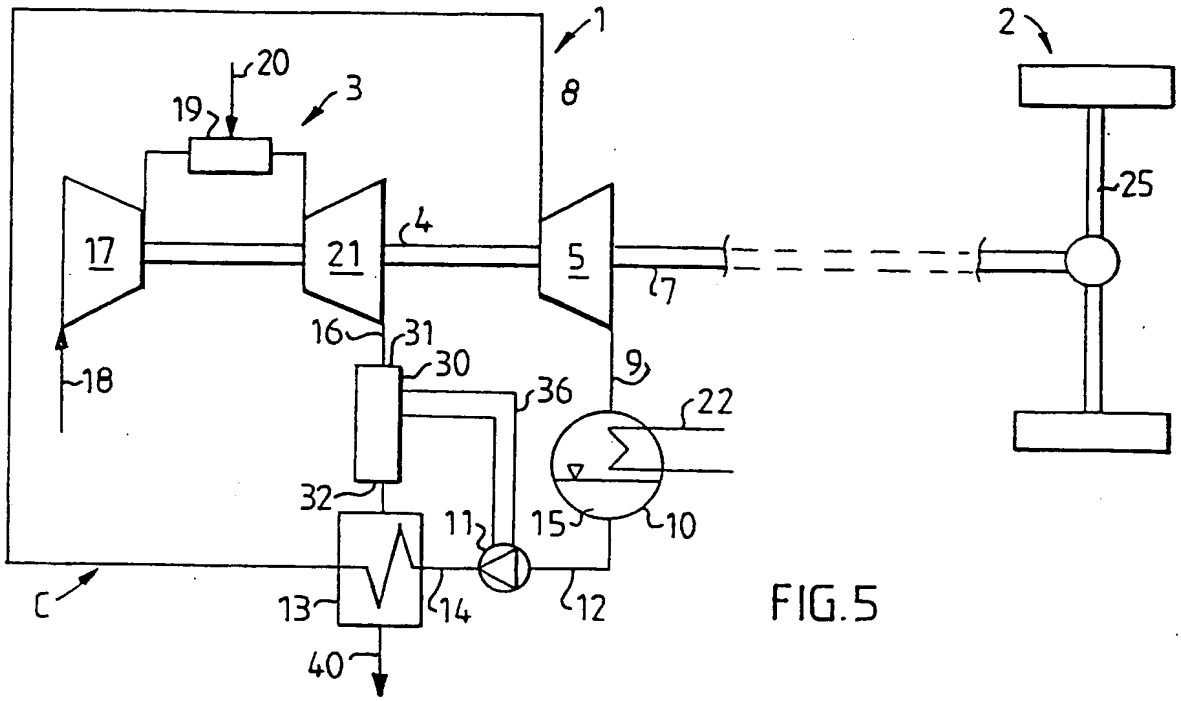

FIG.5

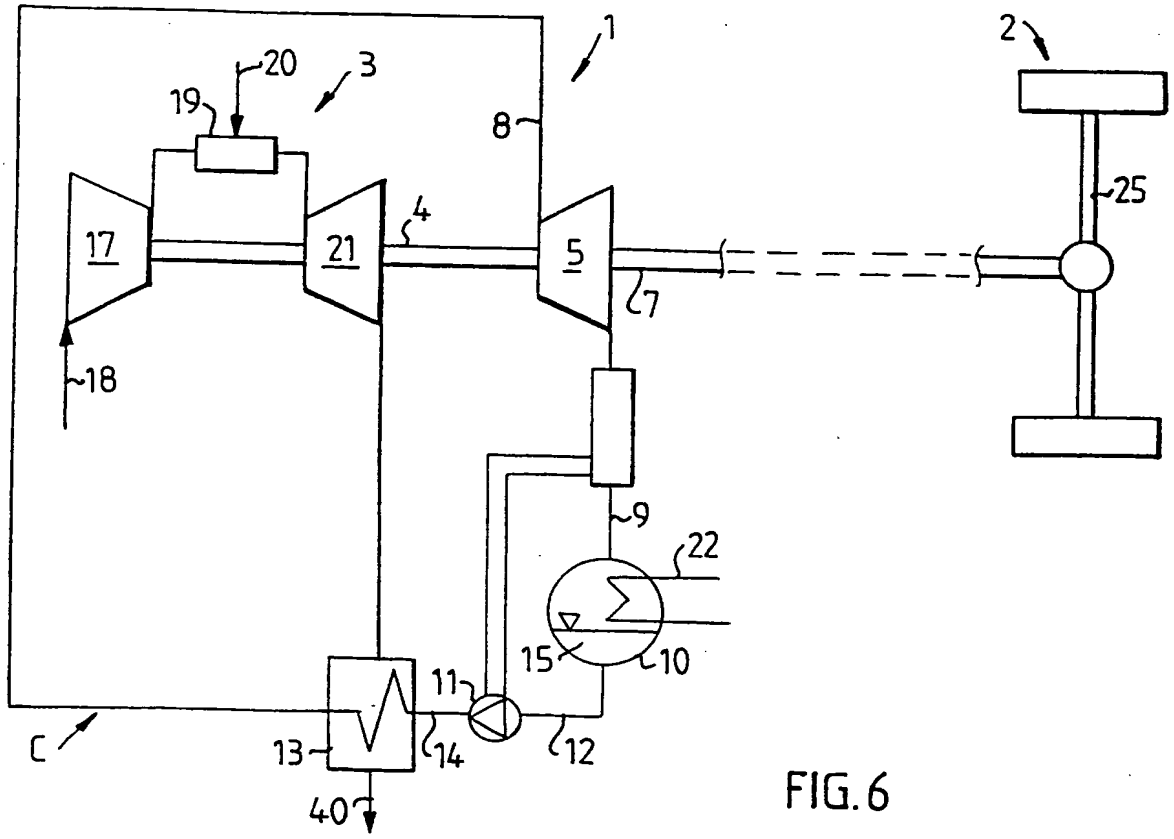

FIG.6

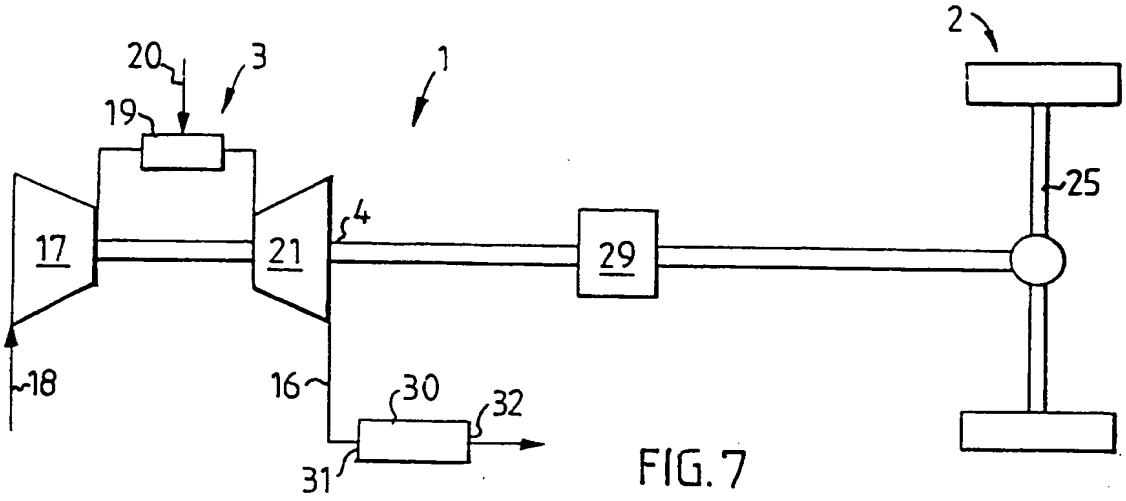

FIG. 7

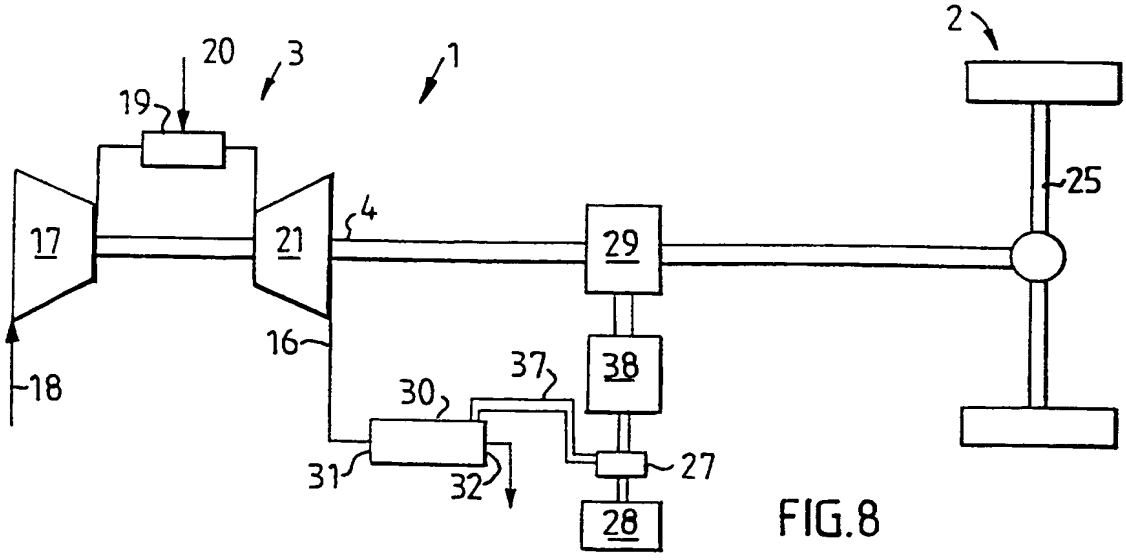

FIG. 8

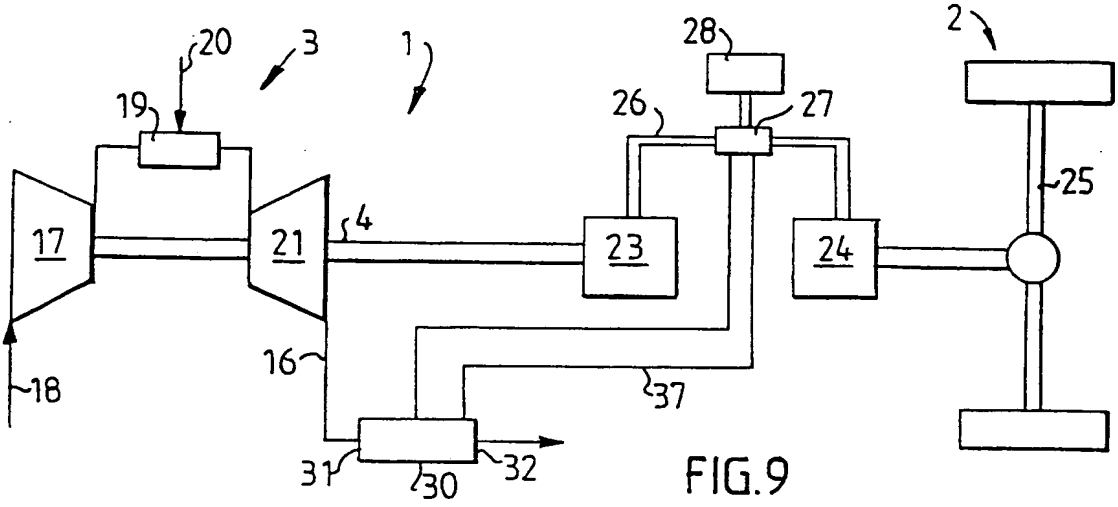

FIG.9

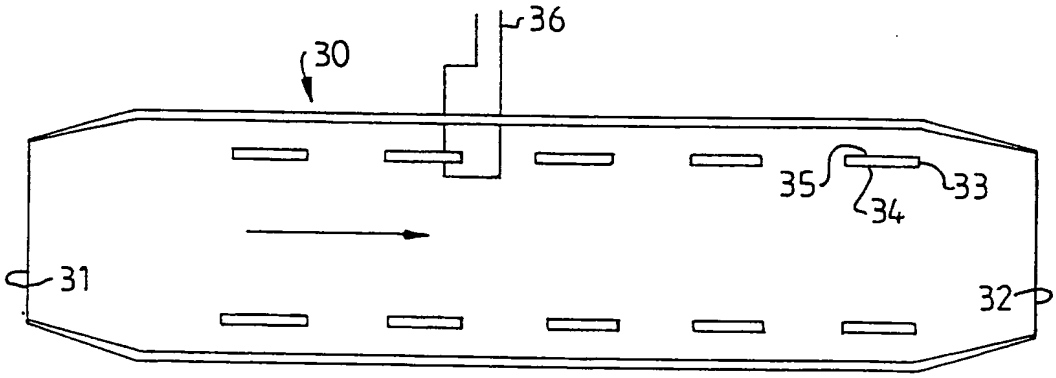

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/01004

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B60K 3/04, B60K 6/02, F01K 15/02
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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4554989 A (GRUICH ET AL.), 26 November 1985 (26.11.85), column 3, line 50 - line 68, figure 2, abstract --	1-15
Y	US 2717491 A (J.C. BARR), 13 Sept 1955 (13.09.55), column 2, line 29 - line 35; column 3, line 29 - line 41, figure 2 --	1-12
Y	WO 8505406 A1 (SWARBRICK, ALAN), 5 December 1985 (05.12.85), page 2, line 21 - page 3, line 13, figure 1 --	9-15

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
21 August 1998	11 -09- 1998
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Form PCT/ISA 210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/01004

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

27/07/98

International application No.
PCT/SE 98/01004

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